

Keysight Technologies

Electronic Calibration (ECal) Modules for Vector Network Analyzers

N4690 Series, 2-port Microwave ECal

85090 Series, 2-port RF ECal

N4430 Series, 4-port ECal

N7550 Series, 2-port ECal

Technical Overview



Overview

Electronic calibration (ECal) is a precision, single-connection, one-, two-, three-, or four-port calibration technique for your vector network analyzer. ECal modules use fully traceable and verifiable electronic impedance standards. The modules are state-of-the-art, solid-state devices with programmable and highly repeatable impedance states. ECal modules are transfer standards that provide consistent calibrations and eliminate operator errors while bringing convenience and simplicity to your calibration routine. Consistent calibrations provide consistent measurements.

ECal replaces the traditional calibration technique, which uses mechanical standards. With mechanical standards you are required to make numerous connections to the test ports for a single calibration. These traditional calibrations require intensive operator interaction, which is prone to error. With ECal, a full one- to four-port calibration can be accomplished with a single connection to the ECal module and minimal operator interaction. This results in faster and more repeatable calibrations.

Mixed-connector options are available for the 85092C, 85093C, 85098C, N4431B and N4432A. The available connectors are Type-N 50 Ω , 3.5 mm, and 7-16.

Control ECal directly from the PNA, ENA, PXI VNA or FieldFox

- DC to 26.5 GHz module
- 10 MHz to 67 GHz module
- Nine connector types available
- Ideal calibration technique for manufacturing
- Mixed-connectors available (Type-N 50 Ω , 3.5 mm and 7-16)

Accurate Transfer Standards

The ECal modules are transfer standards capable of transferring the factory calibration accuracy to your network analyzer. They are characterized by Keysight Technologies, Inc. using a precision calibration technique (similar in accuracy to TRL) that is traceable to the National Institute of Standards and Technology (NIST). Each calibration module's unique S-parameter data is stored in the module's memory. During calibration, ECal uses this data to calculate the error terms for your network analyzer. All measurements on either insertable or non-insertable devices are traceable to NIST.

Faster Calibration with a Single Connection

Unlike the traditional mechanical technique, ECal only requires one connection to perform a full one- to four-port calibration from the calibration module to the test ports. By reducing the number of connections required for a calibration, you can

- Calibrate faster, so you save time and make measurements sooner
- Reduce the chance of operator error, for greater confidence in your calibrations
- Reduce the wear on connectors, for lower repair costs on both the test port connectors and calibration standards

Network Analyzer Compatibility

The 85090 family of RF ECal modules provides calibration across the frequency range of the ENA and 8753 series of network analyzers. The N4690 family of microwave ECal modules provides calibrations through 67 GHz for PNA-X and PNA network analyzers. The N4430 family of four-port modules provide calibration for the ENA, PNA, PXI VNA and any multiport solutions.

Suggested ECal and Network Analyzer Compatibility¹

| Keysight VNA models | ECal module model number |
|-------------------------|---|
| ENA Series ² | 85090 Series, N4430 Series, N7550 Series ⁶ , N4690 Series ⁷ |
| PNA Series ³ | N4430 Series, N7550 Series ⁶ , N4690 Series |
| PXI VNA ⁴ | 85090 Series, N4430 Series, N7550 Series ⁶ , N4690 Series |
| FieldFox ⁵ | N7550 Series ⁶ |

1. For complete compatibility refer to the ECal Reference Guide (publication N4693-90001).
2. ENA Series consists of E5061/62/63, E5070/71/72, and E5080.
3. PNA Series consists of N522X, N523X, and N524X.
4. PXI VNA consists of M937X and M9485A.
5. FieldFox consists of N9923, N9913/4/5/6/7/8, N9925/6/7/8, N9950/1/2.
6. N7550 Series is supported on the latest ENA Series (E5061B/63A/71C/72A/80A), PNA Series (N522X/3X/4X), PXI VNA (M937X, M9485A) and FieldFox (N9923, N991X, N992X, N995X)
7. Exception: the N4693A and N4694A are not supported on the ENA Series except for the E5080.

Simple Non-Insertable Calibrations

Most common RF and microwave components have non-insertable connectors; for example, devices with female connectors on both ports. These devices require an adapter removal calibration, which adds an uncertainty factor to the measurement. Most modern vector network analyzers use an adapter removal technique, which compensates for adapter caused errors.

The simplest and fastest non-insertable calibration method uses an ECal module with connectors that match your device, and the same calibration method as insertable devices. Simply order your ECal module with connectors that match your device under test:

- Option 00M, 3MM, or NMM with male connectors on both ports
- Option 00F, 3FF, or NFF with female connectors on both ports
- Option M0F, 3MF, or NMF with one male and one female connector

Perform adapter removal calibrations faster

Some analyzers, such as later versions of the 8753 and 8720, offer adapter removal calibration for non-insertable and mixed connector measurement capability. Since this method requires two full two-port calibrations, it is often time consuming and prone to operator errors. Using ECal to perform the two-port calibrations addresses both of these concerns by reducing the calibration time and the number of connections, simplifying the overall adapter removal process.

Perform a user-characterization

Normally, when you perform a calibration with an ECal module, the error terms for a calibration are computed using the factory characterization (data) stored in the module. User-characterization allows you to change the characterization of the module in two ways:

- Change the connector configuration: allows you to add an adapter or fixture to the test port of the module and embed the effects into the characterization of the module. The result of the new characterization extends the reference plane from one or more of the module's test ports to those on the adapter (or fixture).
- Modify the state settings: allows you to specify the number of data points (1601 maximum) or other stimulus settings the module uses to perform a calibration.

When you perform a user-characterization, the factory characterization data remains stored in the module's memory. At calibration, you can select the factory characterization or any of the user-defined characterizations stored in the module. The module can store up to five user-defined characterizations (in addition to the factory characterization data). User-characterization is available with PNA and ENA Series Network Analyzers.

Input Power Level

Before performing a calibration, make sure the input power and DC levels do not exceed the values indicated in the table below.

Input power limits

| Parameter | ECal Module Model Number | | | | |
|---|--------------------------|-----------|---------------|-----------|------------|
| | 8509X | N4431X | N4432A/N4433A | N755XA | N469X |
| Typical maximum input power | +9.0 dBm | +7.0 dBm | -7.0 dBm | -15 dBm | -5.0 dBm |
| Typical maximum DC level applied to test port | ± 20 volts | ± 3 volts | ± 3 volts | 0 volts | ± 10 volts |
| Typical damage level | +20.0 dBm | +20.0 dBm | +20.0 dBm | +10.0 dBm | +10.0 dBm |

Operating temperature

The temperature of the ECal module must be within the following temperature range to meet the operating specifications.

- 8509x Series: +20 to +30 °C
- N443xA/B Series: +20 to +30 °C
- N469xA/B Series: +20 to +26 °C
- N755xA Series: +15 to +35°C and up to 75 % relative humidity (RH)

Characteristic Performance

Characteristic performance for RF and microwave ECal modules are provided in the following tables, which describe non-warranted performance that most units exhibit.

8509x Series

| Parameter | Frequency range | | | | |
|--|-------------------|-----------------|------------|------------|------------|
| | 300 kHz to 10 MHz | 10 MHz to 1 GHz | 1 to 3 GHz | 3 to 6 GHz | 6 to 9 GHz |
| Directivity (dB) | 45 | 52 | 52 | 50 | 45 |
| Source match (dB) | 36 | 45 | 44 | 41 | 34 |
| Reflection tracking (\pm dB) | 0.1 | 0.04 | 0.04 | 0.07 | 0.1 |
| Transmission tracking (\pm dB) ² | 0.08 | 0.05 | 0.05 | 0.07 | 0.15 |
| Load match (dB) ² | 40 | 46 | 45 | 43 | 38 |

| Parameter | Frequency range | | | | |
|--|-------------------|-----------------|------------|------------|------------|
| | 300 kHz to 10 MHz | 10 MHz to 1 GHz | 1 to 3 GHz | 3 to 6 GHz | 6 to 9 GHz |
| Directivity (dB) | 45 | 52 | 52 | 49 | 45 |
| Source match (dB) | 36 | 45 | 44 | 41 | 36 |
| Reflection tracking (\pm dB) | 0.1 | 0.04 | 0.04 | 0.06 | 0.07 |
| Transmission tracking (\pm dB) ² | 0.12 | 0.05 | 0.06 | 0.11 | 0.17 |
| Load match (dB) ² | 36 | 41 | 45 | 40 | 37 |

| Parameter | Frequency range | | | | |
|--|-------------------|-----------------|------------|------------|------------|
| | 300 kHz to 10 MHz | 10 MHz to 1 GHz | 1 to 3 GHz | 3 to 6 GHz | 6 to 9 GHz |
| Directivity (dB) | 45 | 52 | 52 | 50 | 47 |
| Source match (dB) | 36 | 44 | 44 | 39 | 34 |
| Reflection tracking (\pm dB) | 0.1 | 0.03 | 0.04 | 0.05 | 0.07 |
| Transmission tracking (\pm dB) ² | 0.13 | 0.05 | 0.05 | 0.10 | 0.16 |
| Load match (dB) ² | 36 | 42 | 45 | 42 | 39 |

1. When applied power exceeds +9 dBm, calibration results will be degraded from the performance indicated in this table.

2. Values based on using the network analyzer N5231A Option 200.

| Parameter | Frequency range | | | |
|--|-------------------|---------------|--------------------|--------------|
| | 300 kHz to 10 MHz | 10 to 300 MHz | 300 MHz to 1.3 GHz | 1.3 to 3 GHz |
| Directivity (dB) | 45 | 50 | 48 | 43 |
| Source match (dB) | 36 | 48 | 45 | 38 |
| Reflection tracking (\pm dB) | 0.10 | 0.03 | 0.06 | 0.10 |
| Transmission tracking (\pm dB) ² | 0.13 | 0.05 | 0.06 | 0.10 |
| Load match (dB) ² | 36 | 42 | 41 | 37 |

1. When applied power exceeds +9 dBm, calibration results will be degraded from the performance indicated in this table.

2. Values based on using the network analyzer E5061B Option 237.

| Parameter | Frequency range | | | | |
|--|-------------------|-----------------|------------|------------|--------------|
| | 300 kHz to 10 MHz | 10 MHz to 1 GHz | 1 to 3 GHz | 3 to 6 GHz | 6 to 7.5 GHz |
| Directivity (dB) | 45 | 47 | 47 | 46 | 45 |
| Source match (dB) | 36 | 43 | 46 | 38 | 37 |
| Reflection tracking (\pm dB) | 0.10 | 0.03 | 0.03 | 0.05 | 0.06 |
| Transmission tracking (\pm dB) ² | 0.13 | 0.06 | 0.07 | 0.12 | 0.14 |
| Load match (dB) ² | 36 | 40 | 38 | 36 | 34 |

1. When applied power exceeds +9 dBm, calibration results will be degraded from the performance indicated in this table.
2. Values based on using the network analyzer N5231A Option 200.

| Parameter | Frequency range | | | |
|--|-------------------|---------------|--------------------|--------------|
| | 300 kHz to 10 MHz | 10 to 300 MHz | 300 MHz to 1.3 GHz | 1.3 to 3 GHz |
| Directivity (dB) | 45 | 50 | 48 | 43 |
| Source match (dB) | 36 | 48 | 45 | 38 |
| Reflection tracking (\pm dB) | 0.10 | 0.03 | 0.07 | 0.15 |
| Transmission tracking (\pm dB) ³ | 0.13 | 0.05 | 0.07 | 0.11 |
| Load match (dB) ³ | 36 | 42 | 41 | 36 |

1. When mated with male connectors with a 0.77 mm (.030 in) to 0.85 (0.34) pin diameter.
2. When applied power exceeds +9 dBm, calibration results will be degraded from the performance indicated in this table.
3. Values based on using the network analyzer E5061B Option 237.

N4431B (3.5 mm)

The characteristic performance in the following table applies to N4431B Option 010 (3.5 mm female connectors on all ports). The data describes performance when measuring “thru path” A-B, C-D, A-D and B-C.

| Parameter | Frequency range | | | | | | |
|--|------------------------------|-----------------|------------|------------|------------|------------|---------------|
| | 9 kHz ² to 10 MHz | 10 MHz to 1 GHz | 1 to 3 GHz | 3 to 6 GHz | 6 to 8 GHz | 8 to 9 GHz | 9 to 13.5 GHz |
| Directivity (dB) | 45 | 53 | 52 | 48 | 46 | 44 | 40 |
| Source match (dB) | 36 | 50 | 47 | 45 | 44 | 43 | 32 |
| Reflection tracking (\pm dB) | 0.10 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.10 |
| Transmission tracking (\pm dB) ³ | 0.10 | 0.04 | 0.06 | 0.12 | 0.16 | 0.17 | 0.44 |
| Load match (dB) ³ | 39 | 45 | 45 | 40 | 38 | 36 | 32 |

The characteristic performance in the following table applies to N4431B Option 010 (3.5 mm female connectors on all ports). The data describes performance when measuring “thru path” A-C and B-D.

| Parameter | Frequency range | | | | | | |
|--|------------------------------|-----------------|------------|------------|------------|------------|---------------|
| | 9 kHz ² to 10 MHz | 10 MHz to 1 GHz | 1 to 3 GHz | 3 to 6 GHz | 6 to 8 GHz | 8 to 9 GHz | 9 to 13.5 GHz |
| Directivity (dB) | 45 | 53 | 52 | 48 | 46 | 44 | 40 |
| Source match (dB) | 36 | 50 | 47 | 45 | 44 | 43 | 32 |
| Reflection tracking (\pm dB) | 0.10 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.10 |
| Transmission tracking (\pm dB) ³ | 0.10 | 0.04 | 0.06 | 0.11 | 0.14 | 0.15 | 0.30 |
| Load match (dB) ³ | 38 | 45 | 45 | 40 | 38 | 36 | 32 |

1. When applied power exceeds +7 dBm, calibration results will be degraded from the performance indicated in this table.
2. Performance from 9 kHz to 300 kHz is valid only for the E5071C ENA network analyzer with firmware version A.09.10 or higher.
3. Values based on using the network analyzer N5231A Option 400.

N4431B (Type-N 50 Ω)

The characteristic performance in the following table applies to N4431B Option 020 (type-N female connectors on all ports). The data describes performance when measuring “thru path” A-B, C-D, A-D and B-C.

| Parameter | Frequency range | | | | | | |
|---|------------------------------|-----------------|------------|------------|------------|------------|---------------|
| | 9 kHz ² to 10 MHz | 10 MHz to 1 GHz | 1 to 3 GHz | 3 to 6 GHz | 6 to 8 GHz | 8 to 9 GHz | 9 to 13.5 GHz |
| Directivity (dB) | 45 | 53 | 52 | 46 | 44 | 42 | 38 |
| Source match (dB) | 36 | 47 | 43 | 42 | 40 | 39 | 31 |
| Reflection tracking (± dB) | 0.10 | 0.03 | 0.04 | 0.04 | 0.05 | 0.06 | 0.11 |
| Transmission tracking (± dB) ³ | 0.10 | 0.04 | 0.07 | 0.12 | 0.16 | 0.18 | 0.45 |
| Load match (dB) ³ | 39 | 45 | 44 | 39 | 37 | 35 | 31 |

The characteristic performance in the following table applies to N4431B Option 020 (type-N female connectors on all ports). The data describes performance when measuring “thru path” A-C and B-D.

| Parameter | Frequency range | | | | | | |
|---|------------------------------|-----------------|------------|------------|------------|------------|---------------|
| | 9 kHz ² to 10 MHz | 10 MHz to 1 GHz | 1 to 3 GHz | 3 to 6 GHz | 6 to 8 GHz | 8 to 9 GHz | 9 to 13.5 GHz |
| Directivity (dB) | 45 | 53 | 52 | 46 | 44 | 42 | 38 |
| Source match (dB) | 36 | 47 | 43 | 42 | 40 | 39 | 31 |
| Reflection tracking (± dB) | 0.10 | 0.03 | 0.04 | 0.04 | 0.05 | 0.06 | 0.11 |
| Transmission tracking (± dB) ³ | 0.10 | 0.04 | 0.06 | 0.11 | 0.14 | 0.15 | 0.31 |
| Load match (dB) ³ | 39 | 45 | 44 | 39 | 37 | 35 | 31 |

1. When applied power exceeds +7 dBm, calibration results will be degraded from the performance indicated in this table.
2. Performance from 9 kHz to 300 kHz is valid only for the E5071C ENA network analyzer with firmware version A.09.10 or higher.
3. Values based on using the network analyzer N5231A Option 400.

N4432A (Type-N 50 Ω)

The characteristic performance in the following table applies to N4432A Option 020 (type-N female connectors on all ports).

| Parameter | Frequency range | | | | |
|---|-----------------|-----------------|------------|---------------|----------------|
| | 300 k to 10 MHz | 10 MHz to 5 GHz | 5 to 9 GHz | 9 to 13.5 GHz | 13.5 to 18 GHz |
| Directivity (dB) | 45 | 50 | 47 | 41 | 40 |
| Source match (dB) | 35 | 41 | 37 | 34 | 34 |
| Reflection tracking (± dB) | 0.10 | 0.06 | 0.10 | 0.15 | 0.14 |
| Transmission tracking (± dB) ² | 0.18 | 0.05 | 0.10 | 0.17 | 0.21 |
| Load match (dB) ² | 35 | 42 | 39 | 35 | 33 |

N4433A (3.5 mm)

The characteristic performance in the following table applies to N4433A Option 010 (3.5 mm female connectors on all ports).

| Parameter | Frequency range | | | | |
|---|-------------------|-----------------|------------|---------------|----------------|
| | 300 kHz to 10 MHz | 10 MHz to 5 GHz | 5 to 9 GHz | 9 to 13.5 GHz | 13.5 to 20 GHz |
| Directivity (dB) | 45 | 50 | 47 | 45 | 40 |
| Source match (dB) | 36 | 42 | 39 | 37 | 31 |
| Reflection tracking (± dB) | 0.10 | 0.06 | 0.09 | 0.10 | 0.18 |
| Transmission tracking (± dB) ² | 0.18 | 0.06 | 0.09 | 0.12 | 0.23 |
| Load match (dB) ² | 35 | 42 | 39 | 38 | 32 |

1. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.
2. Values based on using the network analyzer N5232A Option 400.

N755xA Series (3.5 mm)

The characteristic performance in the following table applies to N755xA Option 3MF, 3MM or 3FF (3.5 mm connectors).

| Parameter | Frequency range | | | | | | |
|--|-----------------|------------------|--------------|--------------|-------------|--------------|----------------|
| | DC to 500 MHz | 500 MHz to 4 GHz | 4 to 6.5 GHz | 6.5 to 9 GHz | 9 to 14 GHz | 14 to 18 GHz | 18 to 26.5 GHz |
| Directivity (dB) | 42 | 36 | 36 | 36 | 36 | 36 | 36 |
| Source match (dB) | 37 | 30 | 30 | 30 | 28 | 28 | 27 |
| Reflection tacking (\pm dB) | 0.13 | 0.13 | 0.18 | 0.18 | 0.25 | 0.25 | 0.30 |
| Transmission tracking (\pm dB) ² | 0.15 | 0.16 | 0.22 | 0.22 | 0.30 | 0.30 | 0.35 |
| Load match (dB) ² | 34 | 29 | 28 | 22 | 26 | 26 | 24 |

N755xA Series (Type-N 50 Ω)

The characteristic performance in the following table applies to N755xA Option NMF, NMM or NFF (Type-N connectors).

| Parameter | Frequency range | | | | | |
|--|-----------------|------------------|--------------|--------------|-------------|--------------|
| | DC to 500 MHz | 500 MHz to 4 GHz | 4 to 6.5 GHz | 6.5 to 9 GHz | 9 to 14 GHz | 14 to 18 GHz |
| Directivity (dB) | 42 | 36 | 36 | 36 | 36 | 36 |
| Source match (dB) | 37 | 30 | 30 | 30 | 28 | 28 |
| Reflection tacking (\pm dB) | 0.13 | 0.13 | 0.18 | 0.18 | 0.25 | 0.25 |
| Transmission tracking (\pm dB) ² | 0.15 | 0.16 | 0.22 | 0.22 | 0.30 | 0.30 |
| Load match (dB) ² | 34 | 29 | 28 | 22 | 26 | 26 |

1. When applied power exceeds -15 dBm, calibration results will be degraded from the performance indicated in this table.

2. Values based on using the network analyzer N5234A Option 200.

N469xA/B/C Series

| Parameter | Frequency range | | | | | |
|-----------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| | 300 kHz to 2 MHz | 2 to 10 MHz | 10 to 500 MHz | 500 MHz to 2 GHz | 2 to 10 GHz | 10 to 18 GHz |
| Directivity (dB) | 30 | 40 | 45 | 48 | 44 | 42 |
| Source match (dB) | 28 | 35 | 40 | 43 | 40 | 35 |
| Reflection tacking (\pm dB) | 0.12 | 0.07 | 0.05 | 0.03 | 0.03 | 0.05 |
| Transmission tracking (\pm dB) | 0.37 ² | 0.08 ² | 0.10 ³ | 0.04 ³ | 0.05 ³ | 0.08 ³ |
| Load match (dB) ² | 26 ² | 37 ² | 33 ³ | 42 ³ | 39 ³ | 34 ³ |

| Parameter | Frequency range | | | | | | |
|-----------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| | 300 kHz to 2 MHz | 2 to 10 MHz | 10 to 500 MHz | 500 MHz to 2 GHz | 2 to 10 GHz | 10 to 20 GHz | 20 to 26.5 GHz |
| Directivity (dB) | 31 | 41 | 46 | 52 | 48 | 46 | 44 |
| Source match (dB) | 29 | 36 | 41 | 47 | 45 | 42 | 40 |
| Reflection tacking (\pm dB) | 0.11 | 0.06 | 0.05 | 0.02 | 0.03 | 0.04 | 0.05 |
| Transmission tracking (\pm dB) | 0.37 ² | 0.08 ² | 0.09 ³ | 0.03 ³ | 0.04 ³ | 0.06 ³ | 0.08 ³ |
| Load match (dB) ² | 27 ² | 37 ² | 34 ³ | 46 ³ | 43 ³ | 40 ³ | 38 ³ |

1. When applied power exceeds -5 dBm, calibration results will be degraded from the performance indicated in this table.

2. Values based on using the network analyzer N5231A Option 200.

3. Values based on using the network analyzer N5222A Option 200.

N469xA/B/C Series

| Parameter | Frequency range | | | | | |
|--|---------------------------|---------------|------------------|-------------|--------------|--------------|
| | 10 to 45 MHz ² | 45 to 200 MHz | 200 MHz to 2 GHz | 2 to 20 GHz | 20 to 30 GHz | 30 to 40 GHz |
| Directivity (dB) | 35 | 41 | 45 | 42 | 39 | 38 |
| Source match (dB) | 30 | 36 | 36 | 35 | 30 | 29 |
| Reflection tacking (\pm dB) | 0.10 | 0.08 | 0.08 | 0.08 | 0.10 | 0.10 |
| Transmission tracking (\pm dB) ³ | 0.15 | 0.11 | 0.09 | 0.11 | 0.14 | 0.15 |
| Load match (dB) ³ | 29 | 34 | 35 | 33 | 28 | 27 |

1. When applied power exceeds -5 dBm, calibration results will be degraded from the performance indicated in this table.
2. Based on typical performance.
3. Values based on using the network analyzer N5224A Option 200.

| Parameter | Frequency range | | | | | | |
|--|---------------------------|---------------|------------------|-------------|--------------|--------------|--------------|
| | 10 to 45 MHz ² | 45 to 200 MHz | 200 MHz to 2 GHz | 2 to 10 GHz | 10 to 20 GHz | 20 to 40 GHz | 40 to 50 GHz |
| Directivity (dB) | 32 | 42 | 51 | 49 | 45 | 41 | 36 |
| Source match (dB) | 25 | 44 | 46 | 42 | 37 | 35 | 32 |
| Reflection tacking (\pm dB) | 0.05 | 0.03 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 |
| Transmission tracking (\pm dB) ³ | 0.12 | 0.06 | 0.04 | 0.05 | 0.07 | 0.10 | 0.14 |
| Load match (dB) ³ | 24 | 42 | 45 | 40 | 35 | 33 | 30 |

1. When applied power exceeds -5 dBm, calibration results will be degraded from the performance indicated in this table.
2. Based on typical performance.
3. Values based on using the network analyzer N5225A Option 200.

| Parameter | Frequency range | | | | | | | | |
|--|---------------------------|---------------|------------------|-------------|--------------|--------------|--------------|--------------|--------------|
| | 10 to 45 MHz ² | 45 to 200 MHz | 200 MHz to 2 GHz | 2 to 20 GHz | 20 to 30 GHz | 30 to 40 GHz | 40 to 50 GHz | 50 to 60 GHz | 60 to 67 GHz |
| Directivity (dB) | 33 | 41 | 46 | 47 | 46 | 44 | 42 | 41 | 38 |
| Source match (dB) | 25 | 38 | 38 | 39 | 35 | 34 | 33 | 30 | 27 |
| Reflection tacking (\pm dB) | 0.05 | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
| Transmission tracking (\pm dB) ³ | 0.15 | 0.08 | 0.06 | 0.06 | 0.08 | 0.09 | 0.11 | 0.12 | 0.15 |
| Load match (dB) ³ | 24 | 36 | 36 | 37 | 33 | 32 | 31 | 28 | 26 |

1. When applied power exceeds -5 dBm, calibration results will be degraded from the performance indicated in this table.
2. Based on typical performance.
3. Values based on using the network analyzer N5227A Option 200.

| Parameter | Frequency range | | | | | |
|-----------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| | 300 kHz to 2 MHz | 2 to 10 MHz | 10 to 500 MHz | 500 MHz to 2 GHz | 2 to 10 GHz | 10 to 18 GHz |
| Directivity (dB) | 30 | 40 | 46 | 45 | 47 | 42 |
| Source match (dB) | 28 | 35 | 40 | 40 | 42 | 36 |
| Reflection tacking (\pm dB) | 0.12 | 0.07 | 0.05 | 0.03 | 0.03 | 0.05 |
| Transmission tracking (\pm dB) | 0.37 ² | 0.07 ² | 0.10 ³ | 0.04 ³ | 0.04 ³ | 0.08 ³ |
| Load match (dB) | 26 ² | 37 ² | 33 ³ | 39 ³ | 41 ³ | 34 ³ |

1. When applied power exceeds -5 dBm, calibration results will be degraded from the performance indicated in this table.
2. Values based on using the network analyzer N5231A Option 200.
3. Values based on using the network analyzer N5222A Option 200.

Ordering Information

Select an ECal module based on the connector type required and the frequency range of your vector network analyzer (refer to table below).

ECal modules and available options

2-port

| Connector Type | Frequency Range | ECal Module Model Number | Available Options |
|----------------|--------------------|--------------------------|---|
| Type-F | 300 kHz to 3 GHz | 85099C | 00A, 00F, 00M, UK6, M0F |
| Type-N 50 Ω | DC to 4 GHz | N7550A | NMF, NMM, NFF |
| Type-N 50 Ω | DC to 6.5 GHz | N7551A | NMF, NMM, NFF |
| Type-N 50 Ω | DC to 9 GHz | N7552A | NMF, NMM, NFF |
| Type-N 50 Ω | 300 kHz to 9 GHz | 85092C | 00A, 00F, 00M, UK6, 1A7, A6J, M0F, mixed-connectors |
| Type-N 50 Ω | DC to 14 GHz | N7553A | NMF, NMM, NFF |
| Type-N 50 Ω | DC to 18 GHz | N7554A | NMF, NMM, NFF |
| Type-N 50 Ω | 300 kHz to 18 GHz | N4690C | 00A, 00F, 00M, UK6, 1A7, A6J, M0F |
| Type-N 75 Ω | 300 kHz to 3 GHz | 85096C | 00A, 00F, 00M, UK6, M0F |
| 3.5 mm | DC to 4 GHz | N7550A | 3MF, 3MM, 3FF |
| 3.5 mm | DC to 6.5 GHz | N7551A | 3MF, 3MM, 3FF |
| 3.5 mm | DC to 9 GHz | N7552A | 3MF, 3MM, 3FF |
| 3.5 mm | 300 kHz to 9 GHz | 85093C | 00A, 00F, 00M, UK6, 1A7, A6J, M0F, mixed-connectors |
| 3.5 mm | DC to 14 GHz | N7553A | 3MF, 3MM, 3FF |
| 3.5 mm | DC to 18 GHz | N7554A | 3MF, 3MM, 3FF |
| 3.5 mm | DC to 26.5 GHz | N7555A | 3MF, 3MM, 3FF |
| 7 mm | 300 kHz to 9 GHz | 85091C | UK6, 1A7, A6J |
| 7 mm | 300 kHz to 18 GHz | N4696B | UK6, 1A7, A6J |
| 7-16 | 300 kHz to 7.5 GHz | 85098C | 00A, 00F, 00M, UK6, M0F, mixed-connectors |
| 2.92 mm | 10 MHz to 40 GHz | N4692A | 00A, 00F, 00M, UK6, 1A7, A6J, M0F |
| 2.4 mm | 10 MHz to 50 GHz | N4693A | 00A, 00F, 00M, UK6, 1A7, A6J, M0F |
| 1.85 mm | 10 MHz to 67 GHz | N4694A | 00A, 00F, 00M, UK6, 1A7, A6J, M0F |

4-port

| Connector Type | Frequency Range | ECal Module Model Number | Available Options |
|-----------------------|--------------------------------|--------------------------|---|
| 3.5 mm or Type-N 50 Ω | 9 kHz to 13.5 GHz ¹ | N4431B | 010, 020, UK6, 1A7, A6J, mixed-connectors |
| Type-N 50 Ω | 300 kHz to 18 GHz | N4432A | 020, mixed-connectors |
| Type-N 50 Ω | 300 kHz to 20 GHz | N4433A | 010 |

1. Performance from 9 kHz to 300 kHz is valid only for the E5071C ENA network analyzer with firmware version A.09.10 or higher.

Options

| Option | Description |
|--------|---|
| 00F | Replace f-m connectors on ECal module(s) with f-f connectors |
| 00M | Replace f-m connectors on ECal module(s) with m-m connectors |
| 00A | Adds male-to-male and female-to-female adapters (also adds a 5/16" 90 N-cm (8 in-lb) torque wrench to 3.5 mm modules) |
| 3FF | 3.5-mm f-f connectors on ECal module(s) |
| 3MF | 3.5-mm f-m connectors on ECal module(s) |
| 3MM | 3.5-mm m-m connectors on ECal module(s) |
| NFF | Type-N f-f connectors on ECal module(s) |
| NMF | Type-N f-m connectors on ECal module(s) |
| NMM | Type-N m-m connectors on ECal module(s) |
| 1A7 | ISO 17025 compliant calibration |
| A6J | ANSI Z540 compliant calibration |
| UK6 | Commercial calibration certificate with measured data |
| M0F | f-m connectors on ECal module(s) |
| 010 | Four female, 3.5 mm connectors |
| 020 | Four female, Type-N 50 ohm connectors |

Mixed-connector options

2-port (85092C/3C/8C ECal modules only)

| Model number | Port A option | | | Port B option | | | | | |
|--------------|-------------------|-----|-----|---------------|-----|-----|-------------------|-----|-----|
| | Type | (f) | (m) | Type | (f) | (m) | Type | (f) | (m) |
| 85092C | Type-N 50 Ω | 103 | 104 | 3.5 mm | 201 | 202 | 7-16 ¹ | 205 | 206 |
| 85093C | 3.5 mm | 101 | 102 | Type-N 50 Ω | 203 | 204 | 7-16 ¹ | 205 | 206 |
| 85098C | 7-16 ¹ | 105 | 106 | 3.5 mm | 201 | 202 | Type-N 50 Ω | 203 | 204 |

4-port (N4431B ECal module only)

| Connector type | Port A option | Port B option | Port C option | Port D option |
|-----------------------|---------------|---------------|---------------|---------------|
| 3.5 mm (f) | 101 | 201 | 301 | 401 |
| 3.5 mm (m) | 102 | 202 | 302 | 402 |
| Type-N 50 Ω (f) | 103 | 203 | 303 | 403 |
| Type-N 50 Ω (m) | 104 | 204 | 304 | 404 |
| 7-16 (f) ¹ | 105 | 205 | 305 | 405 |
| 7-16 (m) ¹ | 106 | 206 | 306 | 406 |

1. Limits ECal module high frequency to 7.5 GHz.

4-port (N4432B ECal module only)

| Connector type | Port A option | Port B option | Port C option | Port D option |
|-----------------|---------------|---------------|---------------|---------------|
| 3.5 mm (f) | 101 | 201 | 301 | 401 |
| 3.5 mm (m) | 102 | 202 | 302 | 402 |
| Type-N 50 Ω (f) | 103 | 203 | 303 | 403 |
| Type-N 50 Ω (m) | 104 | 204 | 304 | 404 |

Web Resources

Visit our Web sites, for additional product information and literature.

Electronic calibration (ECal) module: www.keysight.com/find/ecal

PNA Series Network Analyzers: www.keysight.com/find/pna

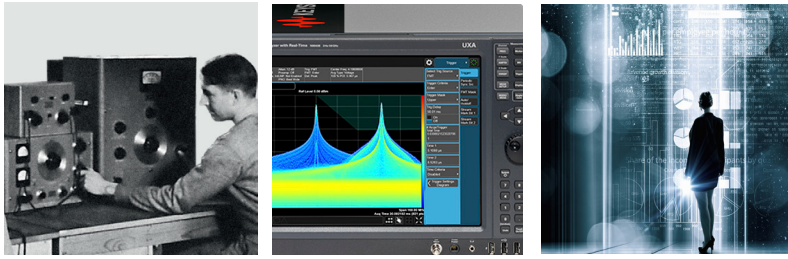
ENA Series Network Analyzers: www.keysight.com/find/ena

PXI Vector Network Analyzers: www.keysight.com/find/pxivna

FieldFox Handheld RF and Microwave Analyzers: www.keysight.com/find/fieldfox

Evolving

Our unique combination of hardware, software, support, and people can help you reach your next breakthrough. **We are unlocking the future of technology.**



From Hewlett-Packard to Agilent to Keysight

myKeysight

myKeysight

www.keysight.com/find/mykeysight

A personalized view into the information most relevant to you.

KEYSIGHT SERVICES

Accelerate Technology Adoption.

Lower costs.

Keysight Services

www.keysight.com/find/service

Our deep offering in design, test, and measurement services deploys an industry-leading array of people, processes, and tools. The result? We help you implement new technologies and engineer improved processes that lower costs.



Three-Year Warranty

www.keysight.com/find/ThreeYearWarranty

Keysight's committed to superior product quality and lower total cost of ownership. Keysight is the only test and measurement company with three-year warranty standard on all instruments, worldwide. And, we provide a one-year warranty on many accessories, calibration devices, systems and custom products.



Keysight Assurance Plans

www.keysight.com/find/AssurancePlans

Up to ten years of protection and no budgetary surprises to ensure your instruments are operating to specification, so you can rely on accurate measurements.

Keysight Channel Partners

www.keysight.com/find/channelpartners

Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

Americas

| | |
|---------------|------------------|
| Canada | (877) 894 4414 |
| Brazil | 55 11 3351 7010 |
| Mexico | 001 800 254 2440 |
| United States | (800) 829 4444 |

Asia Pacific

| | |
|--------------------|----------------|
| Australia | 1 800 629 485 |
| China | 800 810 0189 |
| Hong Kong | 800 938 693 |
| India | 1 800 11 2626 |
| Japan | 0120 (421) 345 |
| Korea | 080 769 0800 |
| Malaysia | 1 800 888 848 |
| Singapore | 1 800 375 8100 |
| Taiwan | 0800 047 866 |
| Other AP Countries | (65) 6375 8100 |

Europe & Middle East

| | |
|----------------|---------------|
| Austria | 0800 001122 |
| Belgium | 0800 58580 |
| Finland | 0800 523252 |
| France | 0805 980333 |
| Germany | 0800 6270999 |
| Ireland | 1800 832700 |
| Israel | 1 809 343051 |
| Italy | 800 599100 |
| Luxembourg | +32 800 58580 |
| Netherlands | 0800 0233200 |
| Russia | 8800 5009286 |
| Spain | 800 000154 |
| Sweden | 0200 882255 |
| Switzerland | 0800 805353 |
| | Opt. 1 (DE) |
| | Opt. 2 (FR) |
| | Opt. 3 (IT) |
| United Kingdom | 0800 0260637 |

For other unlisted countries:

www.keysight.com/find/contactus
(BP-2-23-17)

DEKRA Certified
ISO 9001 Quality Management System

www.keysight.com/go/quality

Keysight Technologies, Inc.
DEKRA Certified ISO 9001:2015
Quality Management System



Unlocking Measurement Insights

This information is subject to change without notice.
© Keysight Technologies, 2013 - 2017
Published in USA, March 13, 2017
5963-3743E
www.keysight.com